

Preliminary Analysis of the Absolute Cartographic Accuracy of the Clementine UVVIS Mosaic

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Thanks to M. Rosiek and D. Cook USGS Astrogeology

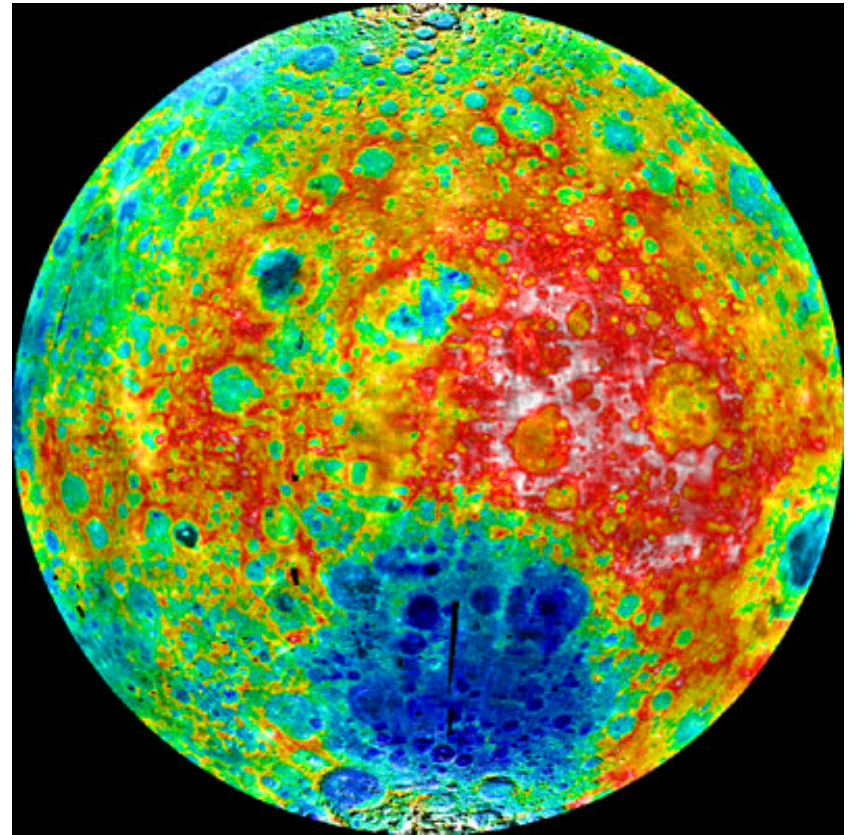
Problem: Evaluating absolute accuracy of Clementine 750 nm basemap

- **43,000 images**
- **265,000 match-points**
- **ground truth from “Apollo zone”, all of
farside floats**
- **no topography used, assumed spherical
Moon of 1737.4 km**
- **spacecraft position**
 - **doppler tracking**
 - **gravity models**

Validate the Farside?

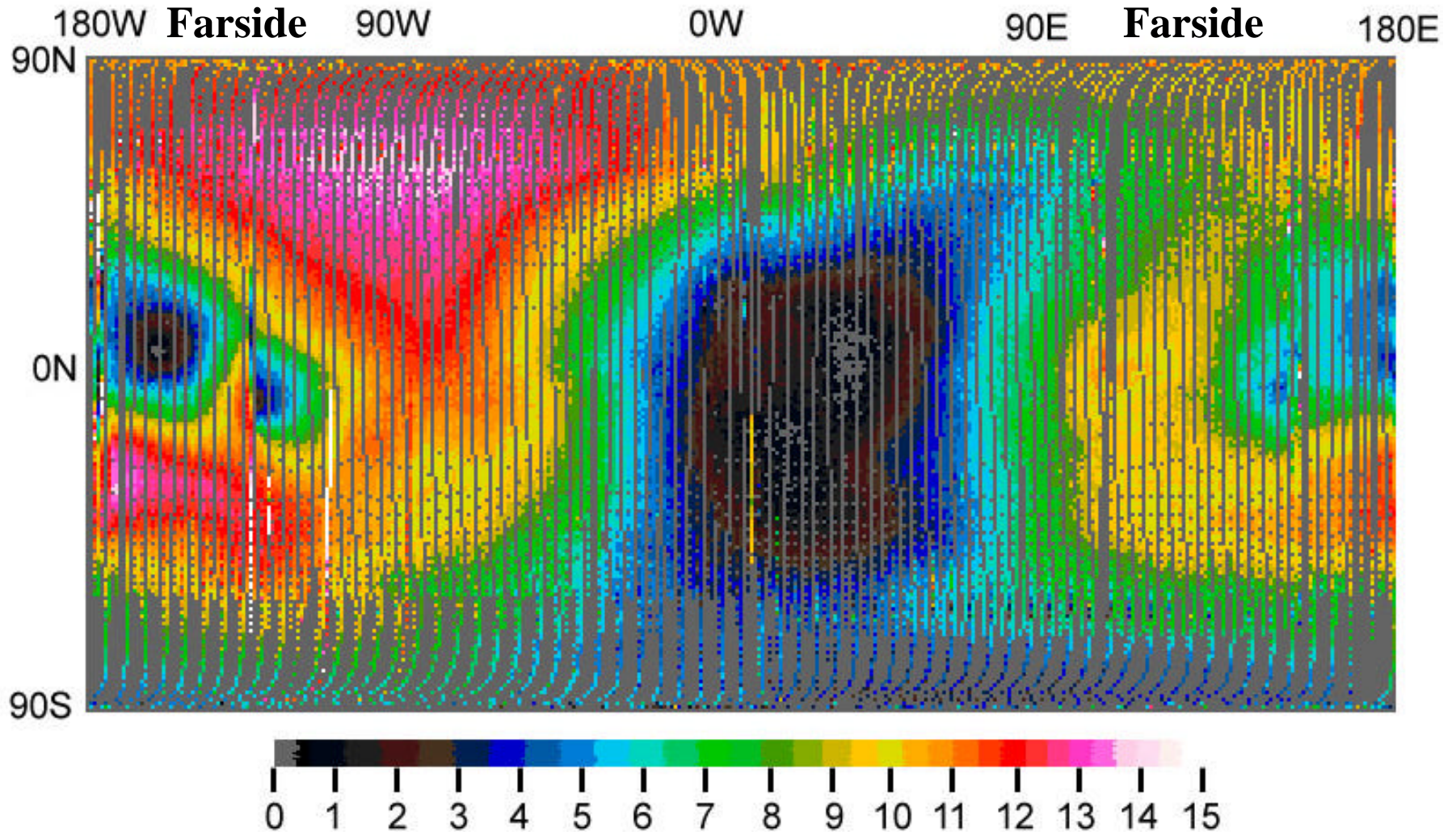
(cartographic sense)

- Recently completed global stereo based topo map
- Used original archived SPICE files (not USGS/Rand control net)
- Overlaid the topo with basemap and found large offsets



Clementine stereo topo on 750 nm basemap

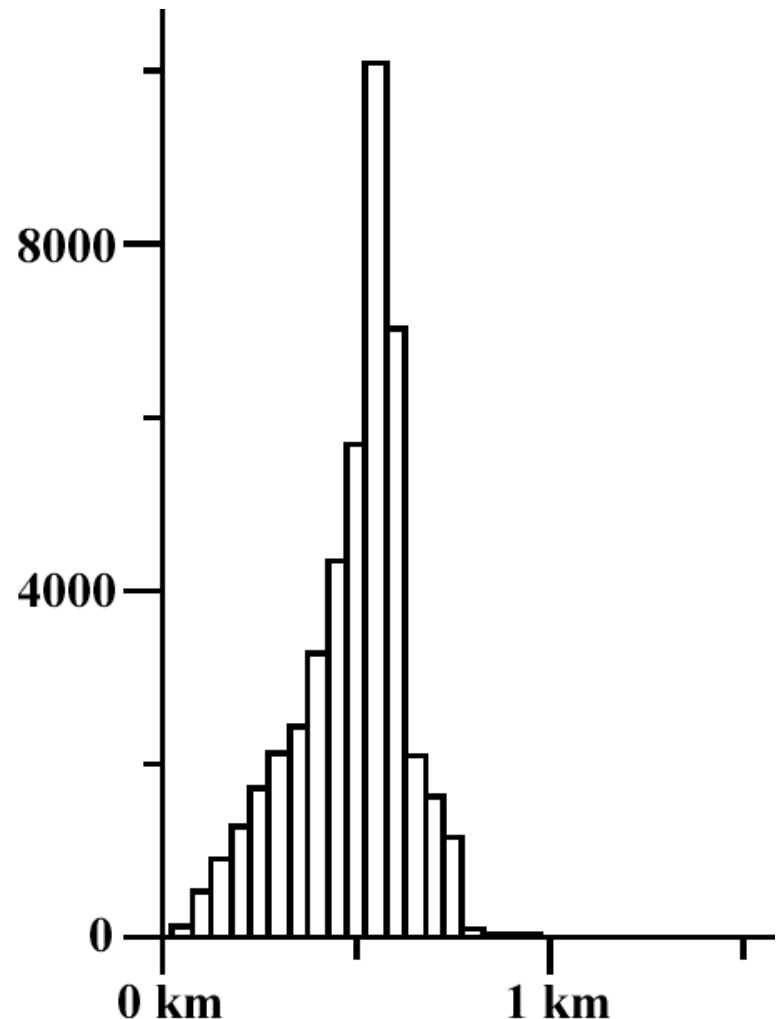
750nm Basemap Geometric Accuracy?



Offset Map: Is this a map of absolute accuracy (lat/lon)?

Spacecraft Position (SPK)

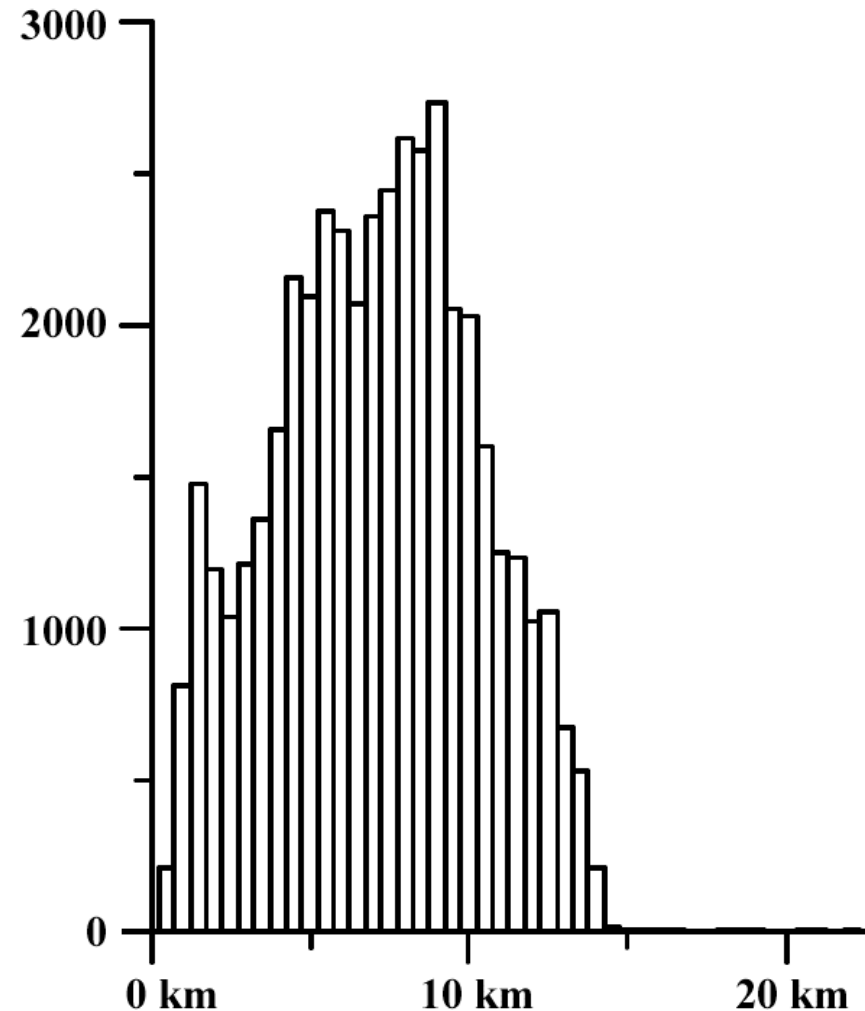
- Small difference in SPK files
- Polar tilt constant differs by 0.022°
- Histogram of sub-spacecraft point differences (max 1 km)



SPK: Cannot explain the observed offsets

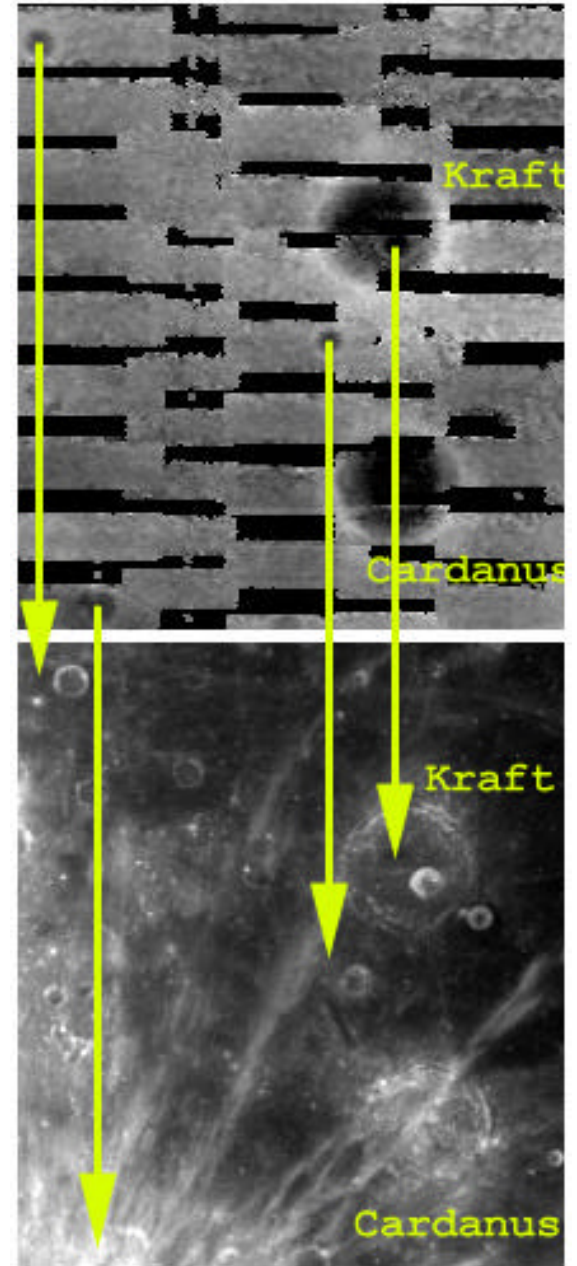
Camera Pointing (CK)

- **USGS/Rand control net should be different than the archived CK (that's what was updated)**
- **And it is! But are these offsets reasonable???**
- **Histogram shows differences USGS/Rand and archived CK (image center points for all 43,000 images in control net)**
- **Image strips overlap by 10-20 pixels (1-2 km near eq)**

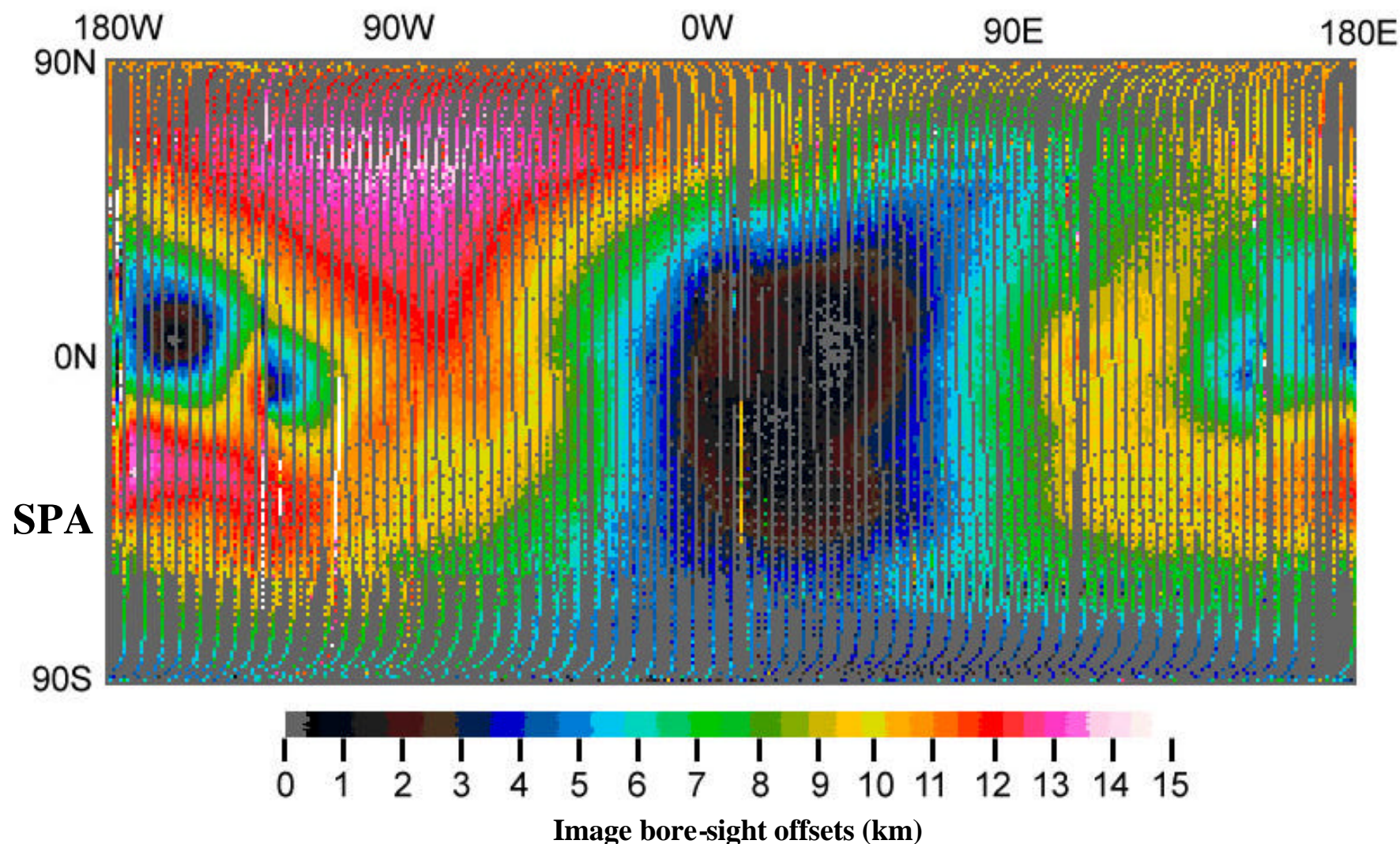


Camera Pointing offsets

- Nearside Apollo zone generally good agreement (<2 km)
- Should be same order for whole Moon otherwise gores between orbits would have occurred
- Outside Apollo zone there were no absolute control points (none exist)
- Control net allowed adjustments up to 10x the accuracy of the spacecraft pointing - is this reasonable?



Simple Cylindrical Projection of Differences in Image Centers from Archived CK & USGS/RAND Control Network



What's Up?

- No absolute control outside the “Apollo Zone”
- Spherical Moon (1737.4km) when in reality there are ± 10 km topographic excursions (SPA and near Korolev crater)
 - Clementine periselene ~ 400 km
 - ± 10 km translates to $\pm 2.5\%$ error in pixel scale
- The lack of control outside Apollo zone results in extrapolation across hundreds of orbits and thousands of images, of these images pixel scale exhibits low frequency error term.

Where are we?

- We believe that the offset map indicates there is a low-frequency error term in the control network which is not in line with the reported 500m absolute accuracy of the basemap (except in the Apollo zone).
- We believe the offset should be 1-2 km everywhere, in line with the accuracy of spacecraft pointing, perhaps a little larger in areas with no direct radio tracking on the central farside.
- We do not know of an unambiguous way to solve this problem with the existing data. Redoing the control network using the low frequency Clementine LIDAR map may improve the solution somewhat-to-considerably. Still - there is no absolute control for >50% of the Moon.

Summary

- Mert Davies had for years cobbled together diverse data of the Moon to make best possible effort at creating lunar control network (Telescopic, LO, Mariner 10, Galileo, Clementine)
- We desperately need a dedicated geodesy mission
- SPA sample return will have to deal with possible positional errors of 10-20 km

